

## Claims

What is claimed is:

1. An apparatus for honing at least one edge on a workpiece, comprising:  
a base;  
a motor mounted to the base;  
an abrasive brush mounted to the motor, the abrasive brush being formed of a plurality of bristles attached to a hub, the bristles each having a tip and an interior end fixed to the hub, the motor adapted to cause the abrasive brush to rotate about an axis of rotation, the abrasive brush having a first end and a second end, and a volume defined by a cylindrical shape extending between said first and second ends with a surface defined by the tips of the bristles, and a radius defined as the distance from the axis of rotation to the tips of the bristles;  
a controller for controlling the rotational speed of the motor; and  
a mount for holding a workpiece, the mount attached to the base, the mount including a fixture for engaging the workpiece to the mount, and a translational movement mechanism adapted to translate the workpiece along a path substantially parallel to the axis of rotation of the abrasive brush.
2. An apparatus according to claim 1, further comprising a depth positioning mechanism for controlling the radial distance between the workpiece edge and the axis of rotation of the abrasive brush.
3. An apparatus according to claim 2, wherein the depth positioning mechanism controls radial movement of the abrasive brush relative to the workpiece edge.
4. An apparatus according to claim 3, further comprising an orientation mechanism for orienting the workpiece edge relative to the abrasive brush.

5. An apparatus according to claim 4, wherein the abrasive brush is engaged to the motor by the hub, the hub including an impeller for forcing cooling air through the bristles of the abrasive brush.

6. An apparatus according to claim 4, further comprising a repositioning device for repositioning the workpiece on the a fixture, the device including a parallel gripper connected to a rotary actuator and a vertical actuator.

7. An apparatus according to claim 4, wherein the fixture is mounted to a rotatable base, the apparatus further comprising a positioning motor engaged with the rotatable base for rotating the fixture on the translational movement mechanism relative to the brush.

8. An apparatus according to claim 2, wherein the depth positioning mechanism controls radial movement of the workpiece edge relative to the abrasive brush.

9. An apparatus according to claim 7, further comprising a device for repositioning the workpiece on the fixture, the device including a parallel gripper connected to a rotary actuator and a vertical actuator.

10. An apparatus according to claim 8, wherein the fixture is mounted to a rotatable base, the apparatus further comprising a positioning motor engaged with the rotatable base for rotating the fixture on the translational movement mechanism.

11. An apparatus for honing at least one edge on a workpiece comprising:  
a base;  
a variable speed motor;  
an abrasive brush mounted to the motor, the abrasive brush being formed of bristles attached to a hub, the bristles each having a tip and an interior end fixed to the hub, the motor adapted to cause the abrasive brush to rotate about an axis of

rotation, the abrasive brush having a first end and a second end, and a volume defined by a cylindrical shape extending between said first and second ends with an outer surface formed by the tips of the plurality of bristles, and a radius defined as the distance from the axis of rotation to the tips of the bristles;

a controller for controlling the rotational speed of the abrasive brush;

a vertical movement mechanism adapted to move the motor along a vertical path in a direction substantially perpendicular to the axis of rotation of the abrasive brush;

a horizontal movement mechanism adapted to control the position of the motor along a horizontal path in a direction substantially perpendicular to the axis of rotation of the abrasive brush; and

a mount for holding a workpiece, the mount being attached to the base and including a fixture adapted to engage the workpiece, and a translational movement mechanism adapted to translate the workpiece along a path substantially parallel to the axis of rotation of the abrasive brush.

12. An apparatus according to claim 11, wherein the translational movement mechanism is adapted to translate the fixture into the volume defined by the bristles.

13. An apparatus according to claim 11, wherein the fixture is mounted to a rotatable base, the apparatus further comprising a positioning motor engaged with the rotatable base for rotating the fixture on the translational movement mechanism relative to the brush.

14. An apparatus according to claim 11, wherein the controller controls the translational movement mechanism.

15. An apparatus according to claim 11, wherein the abrasive brush is engaged to the motor by the hub, the hub including an impeller for forcing cooling air through the bristles of the abrasive brush.

16. An apparatus according to claim 11, further comprising a device for removing and replacing a workpiece on the fixture, the device including a parallel gripper connected to a rotary actuator and a vertical actuator.

17. An apparatus for honing at least one edge on a workpiece comprising:

a base;

a motor;

an abrasive brush mounted to the motor, the abrasive brush being formed of a plurality of bristles attached to a hub, the bristles each having a tip, and an interior end fixed to the hub, the motor adapted to cause the abrasive brush to rotate about an axis of rotation, the abrasive brush having a first end and a second end, and a volume defined by a cylindrical shape extending between said first and second ends with an outer surface defined by the tips of the plurality of bristles, and a radius defined as the distance from the axis of rotation to the tips of the bristles;

a fixture for holding a workpiece;

a translational movement mechanism for moving the fixture in a direction substantially parallel to the axis of rotation of the abrasive brush;

a vertical movement mechanism for moving the fixture in a vertical direction substantially perpendicular to the axis of rotation of the abrasive brush; and

a horizontal movement mechanism for moving the fixture in a horizontal direction substantially perpendicular to the axis of rotation of the abrasive brush.

18. An apparatus according to claim 17, further comprising a controller for sending signals to control the translational movement mechanism, the vertical movement mechanism; and the horizontal movement mechanism.

19. An apparatus according to claim 17, wherein the fixture is mounted to a rotatable base, the apparatus further comprising a positioning motor engaged with the rotatable base for rotating the fixture on the translational movement mechanism relative to the brush.

20. An apparatus according to claim 17, wherein the motor driving the abrasive brush is a variable speed motor, and wherein the speed of the motor is controlled to vary the resulting hone on the workpiece.

21. An apparatus according to claim 17, wherein the abrasive brush is engaged to the motor by the hub, the hub including an impeller for forcing cooling air through the bristles of the abrasive brush.

22. An apparatus according to claim 17, further comprising a repositioning device for changing the position of the workpiece in the fixture, the device including a parallel gripper connected to a rotary actuator and a vertical actuator.

23. An apparatus according to claim 17, wherein the translation movement mechanism is adapted to translate the fixture into the volume defined by the bristles, and wherein the controller provides signals for repositioning the fixture relative to the brush during translation.

24. An apparatus for honing at least one edge on a workpiece comprising:  
a base;

a motor;

an abrasive brush mounted to the motor, the abrasive brush being formed of a plurality of bristles attached to a hub, the bristles each having a tip, and an interior end fixed to the hub, the motor adapted to cause the abrasive brush to rotate about an axis of rotation;

a fixture for holding the workpiece, the fixture being mounted to a rotatable base;

a positioning motor engaged with the rotatable base for rotating the fixture relative to the base;

a controller for controlling rotation of the positioning motor; and

means for controlling the vertical and horizontal distance between the workpiece and the axis of rotation of the abrasive brush.

25. A process for honing at least one edge on a workpiece comprising the steps of:

placing a workpiece in a fixture;

rotating an abrasive brush about an axis of rotation, the abrasive brush including a plurality of abrasive bristles which define a volume;

positioning the workpiece edge relative to the axis of rotation of the abrasive brush such that the workpiece edge to be honed is substantially parallel to the axis of rotation;

positioning the workpiece edge to be honed at a circumferential location relative to the axis of rotation of the abrasive brush, the circumferential position being selected to provide a desired hone shape;

positioning the workpiece edge to be honed at a radial distance from the axis of rotation of the abrasive brush, the distance being less than the radial length of the bristles of the abrasive brush; and

translating the workpiece along a path substantially parallel to the axis of rotation of the abrasive brush such that the workpiece edge passes through at least a portion of the volume of the abrasive brush.

26. The process of claim 25, further comprising the steps of:

re-orienting the workpiece relative to the abrasive brush to position a second workpiece edge to be honed substantially parallel to the axis of rotation after the workpiece has been translated through at least a portion of the volume of the abrasive brush;

positioning the workpiece edge relative to the axis of rotation of the abrasive brush such that the workpiece edge to be honed is substantially parallel to the axis of rotation;

positioning the workpiece edge to be honed at a circumferential location relative to the axis of rotation of the abrasive brush, the circumferential position being selected to provide a desired hone shape;

positioning the workpiece edge to be honed at a radial distance from the axis of rotation of the abrasive brush, the distance being less than the radial length of the bristles of the abrasive brush; and

translating the workpiece along a path substantially parallel to the axis of rotation of the abrasive brush such that the workpiece edge again passes through at least a portion of the volume of the abrasive brush.

27. A process according to claim 25 further comprising the step of adjusting the rotational speed of the abrasive brush to remove a sufficient amount of material from the workpiece to achieve the intended hone shape.

28. A process for honing at least one edge on a workpiece comprising the steps of:

placing a workpiece in a fixture;

rotating an abrasive brush about a rotational axis, the abrasive brush including a plurality of abrasive bristles which define a volume;

adjusting the position of the workpiece edge relative to the axis of rotation of the abrasive brush such that at least a portion of the workpiece edge to be honed is substantially parallel to the axis of rotation of the abrasive brush and in the proper position to be honed;

translating the workpiece along a path substantially parallel to the axis of rotation of the abrasive brush such that the workpiece edge passes through at least a portion of the volume of the abrasive brush.

29. A process according to claim 28 wherein the step of adjusting the position of the workpiece edge relative to the axis of rotation of the brush involves the steps of:

adjusting the vertical distance between the workpiece edge and the axis of rotation of the abrasive brush; and

adjusting the horizontal distance between the workpiece edge and the axis of rotation of the abrasive brush.

30. A process according to claim 29 wherein the step of adjusting the vertical distance involves adjusting the vertical position of the abrasive brush relative to the workpiece; and wherein the step of adjusting the horizontal distance includes moving the abrasive brush relative to the workpiece.

31. A process according to claim 29 wherein the step of adjusting the vertical distance involves adjusting the vertical position of the workpiece relative to the brush; and wherein the step of adjusting the horizontal distance includes moving the workpiece relative to the brush.

32. A process according to claim 29 wherein the step of adjusting the position of the workpiece edge relative to the axis of rotation of the brush involves the step of rotating the workpiece relative to the translational movement mechanism.

33. A process according to claim 28 further comprising the step of rotating the workpiece about a vertical axis.

34. A process according to claim 28 further comprising the step of rotating the workpiece during translation through the bristles to control the resulting hone formed on the workpiece edge.

5           35. A process according to claim 28 wherein the step of adjusting the position of the abrasive brush selectively occurs before, during or after translation of the workpiece.

36. A process according to claim 28 further comprising the step of  
10 adjusting the speed of rotation of the abrasive brush selectably before, during or after translation of the workpiece.

37. A tool formed by the process according to claim 25.

38. A tool comprising a cutting edge that extends from a tip end to a root end, the cutting edge having a controlled hone formed on it which has a shape at the tip end different from the shape at the root end.

39. A tool according to claim 38 wherein the hone shape varies  
5 continuously along the cutting edge from the tip end to the root end.

40. A tool according to claim 38 wherein the tool is a threading tool and wherein the cutting edge is a thread forming edge.

41. A tool having a cutting edge with a hone thereon that varies from a tip end to a root end, the hone being formed in accordance with a process comprising  
10 the steps of:

placing the tool in a fixture;

rotating an abrasive brush about a rotational axis, the abrasive brush including a plurality of abrasive bristles which define a volume;

adjusting the position of the cutting edge relative to the axis of rotation of  
15 the abrasive brush such that at least a portion of the cutting edge to be honed is substantially parallel to the axis of rotation of the abrasive brush and in a desired position to be honed;

translating the tool along a path substantially parallel to the axis of rotation of the abrasive brush such that a portion of the cutting edge passes through at least  
20 a portion of the volume of the abrasive brush to form a hone on the cutting edge having a first shape;

adjusting the position of the cutting edge relative to the axis of rotation of the abrasive brush such that another portion of the cutting edge is substantially parallel to the axis of rotation of the abrasive brush and in a desired position to be  
25 honed; and

translating the tool along a path substantially parallel to the axis of rotation of the abrasive brush such that said other portion of the cutting edge passes through

at least a portion of the volume of the abrasive brush to form a hone on the cutting edge having a second shape different from the first shape.

42. A tool having a cutting edge with a hone thereon that varies from a tip  
end to a root end, the hone being formed in accordance with a process comprising  
5 the steps of:

positioning the cutting edge relative to an abrasive brush rotating about an  
axis of rotation, the abrasive brush having a plurality of abrasive bristles;

translating the tool along a path substantially parallel to the axis of rotation  
of the abrasive brush such that a portion of the cutting edge passes through at least  
10 a portion of the abrasive bristles to form a hone on the cutting edge having a first  
shape; and

repositioning the cutting edge while translating the tool through the abrasive  
bristles such that a second portion of the cutting edge is substantially parallel to the  
axis of rotation of the abrasive brush, the repositioning causing a hone having a  
15 shape different from the first shape to be formed on the second portion of the  
cutting edge being honed.